



# TRANSIT TEMPERATURES OF ICEBERG LETTUCE SHIPPED IN PALLET BINS

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## ABSTRACT

R. Tom Hinsch and C. Max Harris. Transit Temperatures of Iceberg Lettuce Shipped in Pallet Bins. U.S. Department of Agriculture, Marketing Research Report 1098, 7 pp. 1979.

Transit temperatures of western iceberg lettuce packed in bulk bins were determined in four test shipments of fully loaded trailers. Air temperatures in the four loads ranged from a high of 43°F (6.1°C) to a low of 24°F (-4.4°C); lettuce temperature averaged less than 40°F (4.4°C). The lowest lettuce temperatures were at the rear of the trailer where the air returns to the refrigeration unit. Heads of lettuce in the top layer bins were slightly cooler than those in the bottom layer bins. All lettuce temperatures were in an acceptable range during the tests, although not as close to the thermostat setting of 34°F (1.1°C) as would be desirable.

KEYWORDS: lettuce packaging, lettuce transportation, truck refrigeration, pallet bins, cooling, lettuce handling and distribution.

## CONTENTS

	Page
Introduction-----	1
Procedure-----	2
Results-----	4
Product temperatures-----	4
Air temperatures-----	6
Discussion-----	7
Acknowledgments-----	7

## TRANSIT TEMPERATURES OF ICEBERG LETTUCE SHIPPED IN PALLET BINS

By R. Tom Hinsch and C. Max Harris<sup>1</sup>

### INTRODUCTION

Western iceberg lettuce accounts for approximately 20 percent of all carlots of fresh fruits and vegetables shipped from California, and constitutes the largest volume of a single perishable commodity shipped out of State. Lettuce shipments have increased by approximately 26 percent between 1971 and 1975.<sup>2</sup>

Agricultural engineers of the U.S. Department of Agriculture have developed a mechanical lettuce harvester<sup>3</sup> that can harvest the equivalent of about 450 corrugated fiberboard boxes (hereinafter referred to as cartons) of 24 heads each per hour. This rapid harvesting system makes volume filling of large pallet bins feasible.

A survey conducted by a team of USDA scientists revealed that many types of fruits and vegetables were being marketed in bulk pallet bins,<sup>4</sup> and many prepackers and institutional buyers were interested in receiving large pallet bins of lettuce. Previous research by Hinsch and Rij<sup>5</sup> showed that iceberg lettuce could be successfully packed in pallet bins and could arrive in eastern and midwestern markets in a condition comparable to lettuce packed in the conventional 24-head carton. They found, however, that the temperature of lettuce packed in pallet bins rose several degrees Fahrenheit during truck transport

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<sup>2</sup>Anonymous. Shipments of California fruits and vegetables. U.S. Dept. Agr., Agr. Market. Serv., Federal-State Market News Serv., Market News Branch, 21 pp. 1975.

<sup>3</sup>Anonymous. Harvesting lettuce electronically. Agr. Res. 22(7):8-11. 1974.

<sup>4</sup>Rij, R.E., Hinds, R.H., Hinsch, R.T., and Harris, C.M. Current practices and trends in marketing western iceberg lettuce in relation to other produce. U.S. Dept. Agr., Market Res. Rpt. 1052, 9 pp. 1976.

<sup>5</sup>Hinsch, R.T., and Rij, R.E. Packing and shipping mechanically harvested lettuce, U.S. Dept. Agr., Market. Res. Rpt. 1049, 5 pp. 1976.

to eastern receivers when the bins were included in commercial shipments with conventional cartons. The temperature of the lettuce in the conventional cartons did not rise in those tests. Other studies reported on by Harvey,<sup>6</sup> however, have shown that the temperatures of full carton loads of lettuce shipped by truck from California and Arizona to New Orleans also have risen during transit.

The purpose of this study was to determine the temperature of iceberg lettuce packed in pallet bins when shipped in full truck loads to market. Maintaining lettuce temperatures at desired levels of about 34°F (1.1°C) during transportation results in increased salability and reduced losses.

## PROCEDURE

Four shipping tests were conducted to determine transit temperatures of lettuce packed in pallet bins during truck transportation from El Centro, Calif., to distribution warehouses in Richmond and Sacramento, Calif. Non-vented, pallet-bin sleeves were constructed of 1,100 lb test, triple-wall corrugated fiberboard. The bins had outside dimensions of 47 inches long (119.4 cm) by 39 inches wide (99.1 cm) by 36 inches deep (91.4 cm), and were octagonal in shape (fig. 1). Single-wall, corrugated caps with 12 one-inch (2.54 cm) ventilation holes, which provided an area of about 9.4 in<sup>2</sup> (60.8 cm<sup>2</sup>) for vertical ventilation, were used on the tops and bottoms of the sleeves. Prior to filling, the bins were placed on 48- by 40-inch hardwood pallets with two-way entry.

The bins were filled with lettuce in the field on a Thursday. About 15 workers cut, trimmed, and placed lettuce on a mobile conveyor belt that moved through the field (fig. 2). The lettuce was conveyed to the bins, which were carried on an adjoining field truck or trailer. After the bins were filled with about 525 lb (238 kg) of lettuce, they were taken to a vacuum cooler where they were cooled to about 40°F (4.4°C) and loaded into a refrigerated highway trailer. Thirty-six pallet bins, placed two bins wide by two bins high by nine bins long, were loaded into the highway trailer. A 6-inch (15.2-cm) aisle down the center of the trailer facilitated air movement.

In each test, 30 thermocouples were used to monitor the temperature of the lettuce in six of the bins, as well as of the discharge air and air within and around the load in several locations in the truck (fig. 3).

After loading, the thermostat of the refrigeration unit was set on 34°F (1.1°C), and the trailer was taken to the USDA laboratory in Fresno, Calif. The trailer was held over the weekend so temperatures could be monitored, and then was delivered to either Richmond or Sacramento on a following Monday. In each of the four tests, the lettuce was in the trailer for an average of 90 hr to simulate the time required for a cross-country trip.

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<sup>6</sup>Harvey, J.M. Research to improve transit environments for western lettuce. Proceedings of the 26th Annual International Conference on Handling Perishable Agricultural Commodities, East Lansing, Mich., pp. 56-64. 1974.

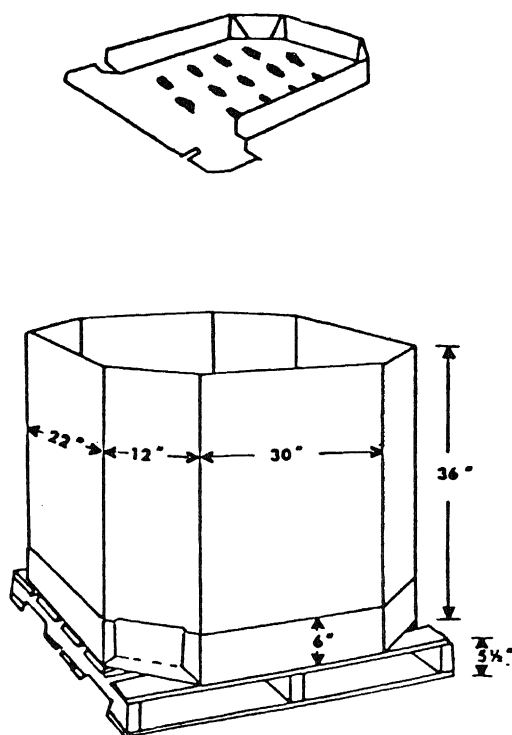


Figure 1.--Diagram illustrating octagonal fiberboard bin. (Note holes in caps to provide vertical ventilation through the bin.)



Figure 2.--Workers placing trimmed lettuce on a mobile conveyor used to fill pallet bins on a field trailer. PN 6420

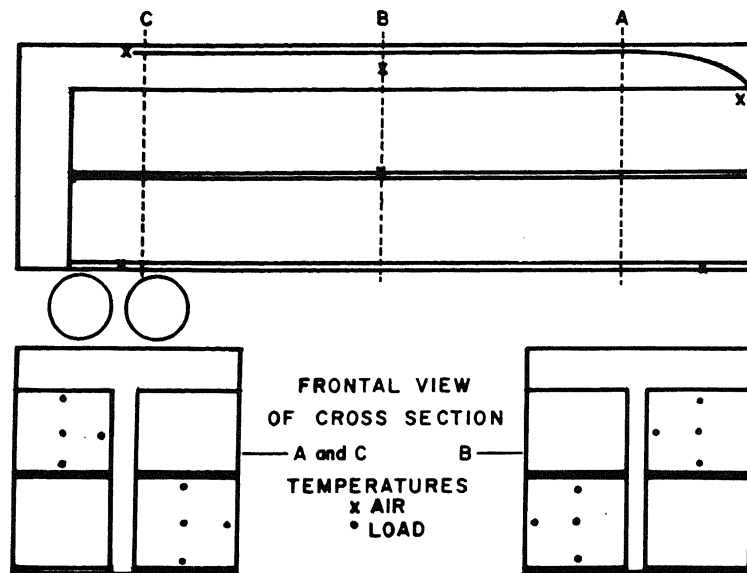


Figure 3.--Thermocouple locations used to monitor air and product temperatures in highway trailers loaded with pallet bins of lettuce. Cross sections at: A = 1/4 length; B = 1/2 length; C = 3/4 length. The bins were stacked two high and two wide in the trailer.

## RESULTS

### Product Temperatures

In each of the four tests, the average lettuce temperature in the bins was maintained at slightly above the thermostat setting of 34°F (1.1°C) (fig. 4). In each test, the lettuce temperatures tended to follow the ambient temperatures, indicating that the particular commercial trailers used had insufficient insulation to prevent conduction of outside heat into the trailer. However, when the ambient temperature dropped, or the trailer was not moving, lettuce temperatures were closer to the thermostat setting.

When the lettuce temperatures were evaluated according to location of the product in the front, middle, or rear of the trailer (fig. 5), the lettuce temperatures at the rear of the trailer were slightly lower than those in the middle or front of the trailer, as would be expected. Since most of the cold airblast from the trailer refrigeration unit is delivered at the rear, product temperatures there tend to be coolest. As the cold air moves forward to return to the refrigeration unit, it picks up heat from the load, which results in warmer air being delivered to the product in the front of the van. The highest average lettuce temperature recorded for the four tests, however, was about 42°F (5.5°C), which is not out of line with commercial shipments of lettuce packed in conventional two-dozen cartons.

The highest individual lettuce temperature recorded for any one of the four test shipments was 44°F (6.7°C), while the lowest individual lettuce temperature recorded was 32°F (0°C). In both instances, the high or low temperature was only momentary and returned to a more acceptable range after a

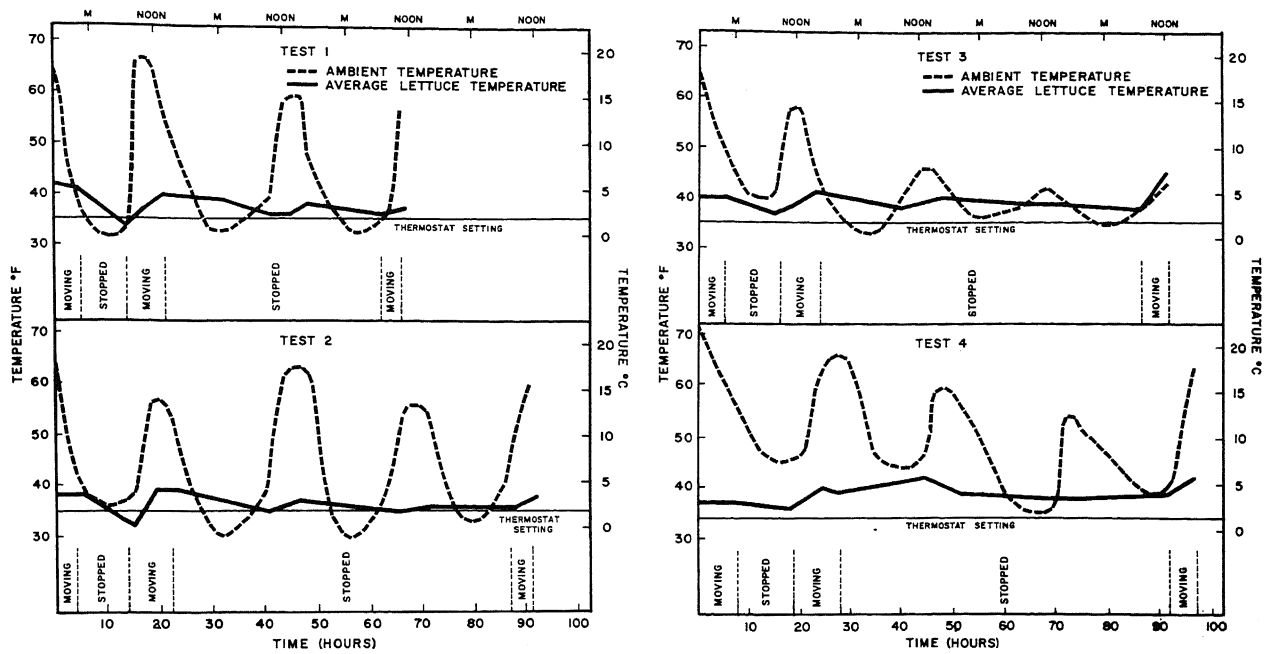


Figure 4.--Average lettuce temperatures in pallet bins, and ambient temperatures during each of four highway trailer tests.

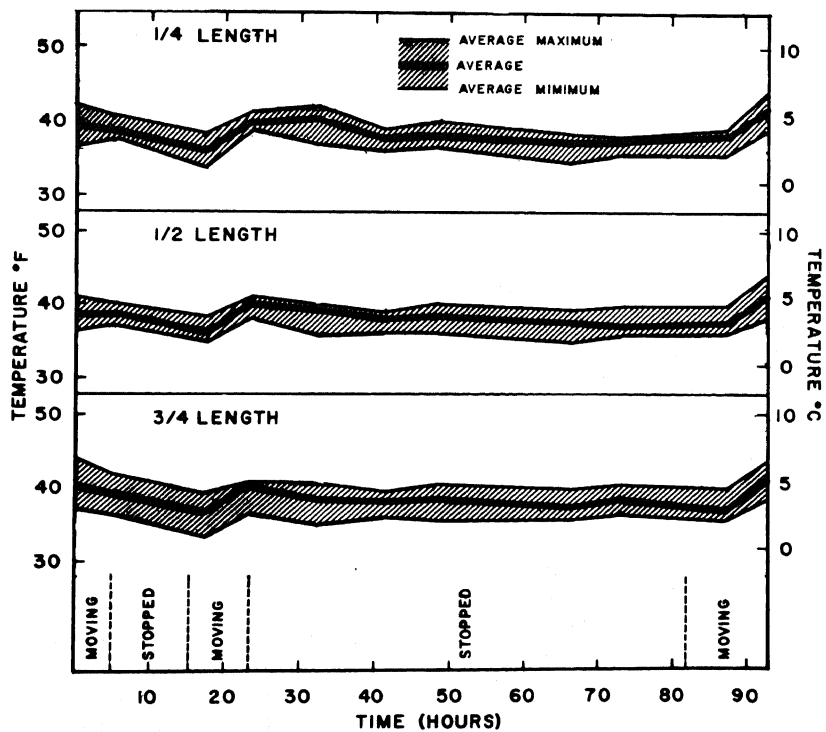


Figure 5.--Temperature range and average temperatures of lettuce in pallet bins located at the 1/4, 1/2, and 3/4 length of four refrigerated trailers.



short period of time.

The bins on the top layer of the trailer were only slightly cooler than those in the bottom layer (fig. 6). This slight difference was probably due to the design of the conventional refrigerated trailer, that is, the cold air is delivered at the top of the load.

The average temperature of the lettuce in the very center of each of the bins was 1° to 4°F (0.5° to 2.2°C) below 40°F (4.4°C) (fig. 6) for all but about 15 hr of the tests. The highest average temperature for the four tests was 42°F (5.5°C). The middle head of lettuce in a bin would receive the least amount of refrigerated air, so it probably stayed cool by conduction. The octagonal shape of the bin also allowed the center head of lettuce to be fairly close to the cold airstream, which seemed to provide acceptable temperature maintenance for the lettuce in the center of the bin.

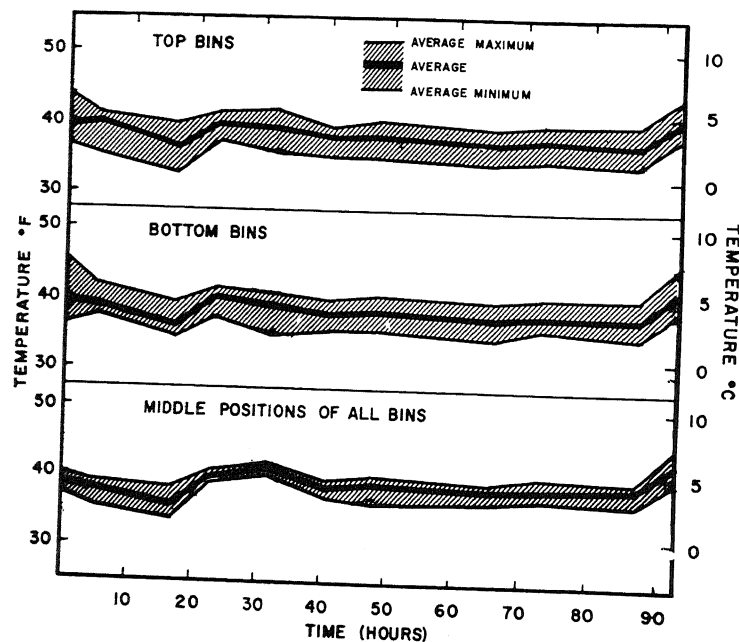


Figure 6.--Temperature range and average temperatures (bold line) of lettuce in pallet bins located on the top of the load, on the bottom of the load, and in the middle of all the bins in the load.

#### Air Temperatures

The discharge air temperature, taken at the duct opening of the refrigeration unit, ranged from a high of 43°F (6.1°C) to a low of 24°F (-4.4°C). The highest readings were taken during the defrost cycle of the refrigeration unit. The lowest readings were at the end of a cooling cycle. The average discharge temperature was 35°F (1.7°C). The thermostat was set on 34°F (1.1°C).

The return air temperature taken after the air has passed through or around the load as it returns to the refrigeration unit, ranged from a high of 46°F (7.8°C) to a low of 30°F (-1.1°C). The average return temperature was

38°F (3.3°C). The return air temperature was always warmer than the discharge temperature except when the refrigeration unit was in the defrost cycle.

## DISCUSSION

In the four transit tests conducted, temperatures of the lettuce averaged below 40°F (4.4°C). Some individual temperatures were above 40°F (4.4°C), but such temperatures also are common in commercial shipments of naked-pack lettuce. If the refrigeration unit had been able to supply constant 34°F (1.1°C) air in the trailer, the lettuce would all be closer to that temperature, but the temperature of the discharge air in the refrigeration units varied widely (19°F or 10.6°C), and constant temperatures could not be maintained. Consequently, the temperature of the lettuce also fluctuated. These results indicate a need for a trailer with a refrigeration unit able to deliver a nearly constant air temperature close to the thermostat setting. In spite of some temperature fluctuation, however, it should be practical to ship lettuce in bulk bins in good refrigerated trailers for transit periods up to 4 days.

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